instruments and work of the Weather Bureau to the class in physical geography of the high school in that city on November 4.

Mr. Charles Stewart, Observer, United States Weather Bureau, Spokane, Wash., reports that on March 21 he addressed the pupils of the Spokane High School, on Weather Changes and their Causes. On April 21 and 22 the pupils visited the Weather Bureau station and were instructed in the nature and use of the apparatus and in other matters connected with meteorology.

Mr. J. B. Marbury, Section Director, Atlanta, Ga., writes, as follows:

On November 13 of this year I delivered a lecture to a class at the Boys' High School in this city. My subject was "The Weather and the science of forecasting." My talk was mainly a preface to others that I have promised to give from time to time as my duties will permit. Much interest was shown in my remarks, which the teacher has since informed me made a deep impression upon his class. The increasing interest shown in the Bureau is, I think, largely due to the lectures and talks given from time to time by the various Weather Bureau officials throughout the country.

SAMUEL B. PFANNER.

In the death of Observer Samuel B. Pfanner, which occurred at Toledo, his native city, on November 2, 1902, the Weather Bureau sustains the loss of a faithful and efficient member of its observing force. Mr. Pfanner was born May 31, 1852. He entered the Weather Service September 2, 1890, and performed duty at Chicago, Ill., Cincinnati, Ohio, New Orleans, La., San Antonio, Tex., and Toledo, Ohio. Recently, his health failing him, his transfer to Phoenix, Ariz., was promptly arranged for at his request, but his illness took a sudden change for the worse, and he died before he could execute the official orders for his transfer which he had received.—*D. J. C.*

AUSTRALIAN DROUGHTS AND THE MOON.

Mr. H. C. Russell, Director of the Observatory at Sydney, New South Wales, has published in the Journal and Proceedings of the Royal Society of New South Wales, for the year 1901, a memoir on the relation of the moon's motion in declination and the quantity of rain in that colony, in which the author concludes "that rain is clearly shown to come in abundance when the moon is in certain degrees of her motion south; but when the moon begins to go north then droughty conditions prevail for seven or even eight years. This phenomenon repeated for three periods of nineteen years each constitutes a marvellous coincidence such that there must be a law connecting the two phenomena."

The influence of the moon on the weather is a matter that will not be downed by the exercise of any amount of common sense. According to the most ancient notions, the moon ought to have and must have a controlling influence in excess of the sun's, and every one who seeks to demonstrate its power is liable to become infatuated with the study. The moon has so many variations north and south of the equator, north and south of the ecliptic, to and from the earth, from new moon to full moon, conspiring with the sun and opposing the sun, that it does seem as though one ought to be able to make its periodical oscillations agree with some of the many variations in the aspect of the weather. However, we know of but one relation between the moon and the earth's atmosphere that can be said to have been settled upon a rational basis and that is the matter of atmospheric tides. Laplace stated that the semidiurnal lunar tide in the atmosphere ought to amount to about 0.003 inches of barometric pressure for equatorial stations, and this agrees with the results of observations carried on at Batavia, Java. His formulæ also showed, although we believe he did not state the fact, that as the moon moves north and south of the equator monthly, there ought to be a fortnightly tide, or a general pull of the atmosphere southward for two weeks and northward for two weeks. This we believe was first demonstrated as an observable quantity by A. Poincaré, a civil engineer of Paris and a member of the Meteorological Society of France. From his articles published by that Society in 1885–1888, we learn that the average barometric pressure on parallels of latitude around the whole globe, as measured on the International Maps published by the United States Weather Bureau, give the following results: The pressure on latitude 40° minus that on latitude 10° is + 1.88 millimeters when the moon is in the extreme south and + 4.82 millimeters when the moon is in the extreme north. The normal difference is + 3.35. This indicates that when the moon is furthest north there is a slight accumulation of atmosphere in the Northern Hemisphere, amounting to an increase of 1.47 millimeter, or 0.06 inch of pressure on the parallel of 40°.

Now, all lunar phenomena go through rather rapid periodic changes. What happens in one part of a lunar month is offset by an opposite effect in the other half of that month, or what happens at the time when the sun and moon conspire is offset by an opposite effect a few months or years later when the sun and moon oppose each other. When the moon is far south and begins to go north, according to Mr. Russell, droughty conditions prevail and continue for seven or eight years. But the strange part is that the moon begins to go north from her extreme southern position every month without exception, not only just before the seven or eight year drought, but during the whole of that long period, and continues to do so during the whole of the succeeding rainy period. How can her beginning to go north be rationally supposed to be a basis for predicting droughts in one case and rains in another?

But if we lay aside all these vagaries about the moon, and recognize Mr. Russell's meteorological induction that droughty conditions do prevail for seven or eight years in Australia, followed by years of rain, and that this cycle of droughts and rains has been repeated about three times since 1840, then, we have a fair observational basis upon which to build a rational explanation. Now, this periodicity, or rather the irregular succession of good seasons and bad seasons is a fact recognized in every portion of the world. We have also enough data to show that in most cases a drought in one portion of the globe is accompanied by rains in other portions, and that the regions of excess and deficiency of rain move over the surface of the globe month by month and year and year. They do not move in courses so nearly parallel as to justify long range predictions any more than do our storm centers, but the movements are certainly governed by laws, and we can begin to generalize as a first step in the process from induction to deduction. For instance, floods in the upper Nile, due to rains in the highlands of central Africa, mean that an unusual proportion of moisture has been taken from the southeast trade wind current, and that, therefore, when that has turned northeastward over the Indian Ocean, and has become the southwest monsoon of India, it will bring droughts over the western portion of that country. A drought in New South Wales, or on the southeast side of Australia, means a deficiency in the easterly winds blowing on that coast, and especially so in the rainy season, or December, January, February, and March. But this means that the great area of high pressure over the Indian Ocean at latitude 30° south has been pushed farther west than usual, or in other words that the general circulation of the atmosphere in that region has been disturbed. Now, such a disturbance, continued over several months or even years, can hardly be produced by the rapidly changing moon; it might be due to secular changes in the quantity and quality of the solar heat, but is most of all, likely to be simply the result of accumulations of pressure, temperature, and moisture in various portions of the earth's atmosphere. Australia has about the same area as the United States, but lies on the average about 15° nearer the equator. This latter feature gives it soil temperatures and monsoon influences similar to those that prevail in northern Africa, so that it may itself produce an appreciable disturbance of the general circulation in the southern half of our atmosphere. But the principal cause of the droughts in Australia and India is undoubtedly to be found in the changes going on periodically in the relation between the general atmospheric pressure and resultant circulation in the south and in the north, or between Cape Colony and Australia, China and eastern Siberia. In this large portion of the globe a system of circulation prevails that is affected but comparatively little by what goes on to the west of it and north of it. A large quantity of air enters into this region from the Antarctic Ocean and passes out of it as the southwest monsoon of southern Asia to eventually become the westerly winds of the North Pacific. We may, therefore, look for some connection by this roundabout way between the droughts and rains of Australia, or southeastern Asia, and those of northwestern America.—*C. A.*

SHADOW BANDS; SCINTILLATION; INTERFERENCE BANDS.

Among the optical phenomena observed in the atmosphere the shadow bands seen on the ground during total solar eclipses just before the beginning and just after the end of totality have excited considerable attention. During the total eclipse of May 28, 1900, they were made the special subject of investigation in connection with Weather Bureau work, as it is highly probable that they originate in the earth's atmosphere. It is very rare that there do not exist in the atmosphere ascending and descending currents of air, which may be on a very minute scale as well as on a large scale. We conceive of the atmosphere as filled with minute masses of smaller density slowly ascending amidst equally minute descending masses of greater density. This mixture of rarer and denser portions produces in general a loss of light and a diminution of sound, which we know under the familiar name of heat-haze and acoustic opacity, respectively. Another effect is perceived when one views a minute source of light, such as a fixed star, and notices that it is apparently wobbling in all directions irregularly. This is undoubtedly due to the irregular refractions of the ray of light, which is bent out of its course by having to pass through so many curved surfaces separating the masses of warm air from those of cold air. In addition to refraction, the ray of light is also subject to prismatic dispersion, and the star is seen to oscillate in color from blue, through green and yellow, to red, especially when it is low down in the horizon. The existence of this mixture of small masses of air having different degrees of refracting power is also very prettily shown when we look at a white surface illuminated by a bright point, such as the electric light. In this case we see the white surface, not of a uniform tint, but spotted all over with dark and bright patches, which are in constant motion corresponding to the movements of the mixed cold and warm currents.

During the progress of a total eclipse the sun's disk is for a few minutes before and after the totality reduced to an exceedingly thin, bright circular arc, whose light throws upon a bright wall, or a white sheet laid upon the ground, visible shadows perfectly analogous to those just referred to as cast by the electric light; the principal differences arise from the fact that the eclipse happens during the warmer daytime and that the sunlight comes from a considerable angular altitude, whereas in the electric light we observe during the cooler night-time, and the beam of light is nearly horizontal and passes through only a small thickness of the lower air. If there were minute waves on a horizontal surface separating two strata of air at some distance above us, then the sunlight refracted at this wave surface would produce simple bands of shadow on the ground analogous to the shadows of the ascending warm air. This is a possible phenomenon, but not one that is likely to occur without being combined with the more important phenomena due to ascending currents analogous to waves in a vertical plane. To these combined horizontal and vertical waves we owe the phenomena of scintillation that have been most patiently observed by Montigny, in the hope of deriving therefrom some additional knowledge of the conditions prevailing in the upper air. But the investigations made, by means of the scintillometer, and especially the complete explanation by Exner and Pernter, of the origin and nature of scintillation have shown that but little of any value to dynamic meteorology can be expected to be derived from this study, although it is important to astronomy. The eclipse of May, 1900, added considerably to the observational data on the shadow bands or the dark fringes, as they are sometimes called. Among the articles written on the subject we note one by G. Johnstone Stoney in the Monthly Notices of the Royal Astronomical Society, vol. 60, p. 586. A memoir by Señor V. Ventosa, Astronomer at the Madrid Observatory, is summarized on page 86, vol. 62, 1900, of the English journal Nature, as follows:

> The examination of the observed facts appears to support the view that these shadow phenomena are not diffraction fringes bordering the actual shadow of the moon, but are produced in the body of our own atmosphere and are affected by the direction of the wind.
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> Señor Ventosa has been occupied for some time in studying the currents in the higher regions of our atmosphere by observing the undulations round the sun and stars with a telescope, and thinks that these upper atmospheric currents may possibly have some bearing on the question of the eclipse shadow bands; the movement of these higher portions showing through the quieter lower strata, and being rendered visible on account of different refractive powers. He thinks it would be useful to determine the velocity of these currents by anemometers at various altitudes, and also to observe the undulations round the limb of the sun at the time of eclipse, comparing them with the shadow bands in direction and velocity of movement. To ascertain if any experimental illustration of this hypothesis could be presented, he states that bands may be produced by passing diffused light reflected from a sheet of corrugated glass through a circular aperture representing the sun, over which an opaque disk, representing the moon, is made to slide. When the segment left uncovered is about 5 mm. in width, alternate bright and dark bands can be observed on a white screen held near, if the length of the segmental opening is approximately parallel to the undulations of the glass; but if at right angles they entirely disappear. * * * This hypothesis shows the advisability of recording the direction and velocity of the wind during eclipses.

The subject of the shadow bands has been especially considered by Prof. F. H. Bigelow in the third chapter of his Eclipse Meteorology and Allied Problems. On page 57, after the collation of observations at many stations, he says:

> The direction of the cusps of the visible arc of the sun and the direction of the shadow bands are generally parallel to each other, and this direction varies distinctly between the center of the path of totality and the edge of the path, yet, keeping up the same parallelism. These two geometric facts are practically decisive in regard to the origin of the bands * * *. We, therefore, dismiss the diffraction theory from further consideration. We are, therefore, brought to conceive of the umbra [or central blackest portion of the moon's shadow] as surrounded by semiopaque rings * * * of such a character that the crescents of the sun's disk will cast down images upon the ground through a flickering and wavy medium. The width of the bands was found to be on the average 1.37 inches before totality, and 1.21 inches after totality; the widths of the bright spaces were 2.15 inches before and 2.24 inches after totality.

Owing to the irregular refractions of sunlight passing through a mixture of small masses of warm and cold or dry and moist air, the air must contain an immense number of small beams of light slightly inclined to each other and some of these produce what are known as optical interference. This subject is explained fully in all treatise on physical optics (see also Watson's text-book of physics). Interference is the cause of numerous well-known phenomena, such as the colors seen on irridescent mother of pearl and the magnificent ruled gratings of Rowland; also the so-called colors of thin plates seen in